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Titolo	Mechanical Signaling in Plants: From Perception to Consequences for Growth and Morphogenesis (Thigmomorphogenesis) and Ecological Significance
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Sommario/riassunto	<p>During the 1970s, renewed interest in plant mechanical signaling led to the discovery that plants subjected to mechanical stimulation develop shorter and thicker axes than undisturbed plants, a syndrome called thigmomorphogenesis. Currently, mechanosensing is being intensively studied because of its involvement in many physiological processes in plants and particularly in the control of plant morphogenesis. From an ecological point of view, the shaping of plant architecture has to be precisely organized in space to ensure light capture as well as mechanical stability. In natural environments terrestrial plants are subjected to mechanical stimulation mainly due to wind, but also due to precipitation, while aquatic and marine plants are subjected to current and wave energy. Plants acclimate to mechanically challenging environments by sensing mechanical stimulations and modifying their growth in length and diameter and their tissue properties to reduce potential for buckling or breakage. From a morphogenetic point of view, both external and internal mechanical cues play an important role in the control of cell division and meristem development likely by modulating microtubule orientation. How mechanical stimulations are being sensed by plants is an area of intense research. Different types of mechanosensors have been discovered or proposed, including ion channels gated by membrane tension (stretch activation) and plasma membrane receptor-like kinases that monitor the cell wall</p>

deformations. Electrophysiologists have measured the conductances of some stretch-activated channels and have showed that SAC of different structures can exhibit different conductances. The role of these differences in conductance has not yet been established. Once a mechanical stimulus has been perceived, it must be converted into a biological signal that can lead to variations of plant phenotype. Calcium has been shown to function as an early second messenger, tightly linked with changes in cytosolic and apoplastic pH. Transcriptional analyses of the effect of mechanical stimulation have revealed a considerable number of differentially expressed genes, some of which appear to be specific to mechanical signal transduction. These genes can thus serve as markers of mechanosensing, for example, in studies attempting to define signalling threshold, or variations of mechanosensitivity (accommodation). Quantitative biomechanical studies have lead to a model of mechanoperception which links mechanical state and plant responses, and provides an integrative tool to study the regulation of mechanosensing. This model includes parameters (sensitivity and threshold) that can be estimated experimentally. It has also been shown that plants are desensitized when exposed to multiple mechanical signals as a function of their mechanical history. Finally, mechanosensing is also involved in osmoregulation or cell expansion. The links between these different processes involving mechanical signalling need further investigation. This frontier research topic provides an overview of the different aspects of mechanical signaling in plants, spanning perception, effects on plant growth and morphogenesis, and broad ecological significance. During the 1970s, renewed interest in plant mechanical signaling led to the discovery that plants subjected to mechanical stimulation develop shorter and thicker axes than undisturbed plants, a syndrome called thigmomorphogenesis. Currently, mechanosensing is being intensively studied because of its involvement in many physiological processes in plants and particularly in the control of plant morphogenesis. From an ecological point of view, the shaping of plant architecture has to be precisely organized in space to ensure light capture as well as mechanical stability. In natural environments terrestrial plants are subjected to mechanical stimulation mainly due to wind, but also due to precipitation, while aquatic and marine plants are subjected to current and wave energy. Plants acclimate to mechanically challenging environments by sensing mechanical stimulations and modifying their growth in length and diameter and their tissue properties to reduce potential for buckling or breakage. From a morphogenetic point of view, both external and internal mechanical cues play an important role in the control of cell division and meristem development likely by modulating microtubule orientation. How mechanical stimulations are being sensed by plants is an area of intense research. Different types of mechanosensors have been discovered or proposed, including ion channels gated by membrane tension (stretch activation) and plasma membrane receptor-like kinases that monitor the cell wall deformations. Electrophysiologists have measured the conductances of some stretch-activated channels and have showed that SAC of different structures can exhibit different conductances. The role of these differences in conductance has not yet been established. Once a mechanical stimulus has been perceived, it must be converted into a biological signal that can lead to variations of plant phenotype. Calcium has been shown to function as an early second messenger, tightly linked with changes in cytosolic and apoplastic pH. Transcriptional analyses of the effect of mechanical stimulation have revealed a considerable number of differentially expressed genes, some of which

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